EMYDURA LAVARACKORUM, A NEW PLEISTOCENE TURTLE (PLEURODIRA:CHELIDAE) FROM FLUVIATILE DEPOSITS AT RIVERSLEIGH, NORTHWESTERN QUEENSLAND.

A. W. WHITE AND M. ARCHER

WHITE, A. W. & ARCHER, M. 1994. *Emydura lavarackorum*, a new Pleistocene turtle (Pleurodira: Chelidae) from fluviatile deposits at Riversleigh, northwestern Queensland. *Rec. S. Aust. Mus.* **27**(2): 159–167.

In 1986 the carapace, plastron and pelvic remains of a large chelid turtle were recovered from Pleistocene sediments on Riversleigh Station in northwestern Queensland. The fossil remains are described herein. The good state of preservation enabled the remains to be placed in an extant genus (*Emydura*) within the Chelidae on the basis of a derived feature of the carapace. Distinctive features such as a wide bridge, broad first vertebral scute, unusual epiplastra–hyoplastron suture, thickened bridge buttresses and deep intergular insertion between the humerals prevent these fossils from being assigned to a known species. Accordingly, a new species of *Emydura* is proposed and comparisons are made between it and the currently recognised congenors.

Arthur W. White and Michael Archer, School of Biological Sciences, University of New South Wales, P.O. Box 1, Kensington, New South Wales, 2033. Manuscript received 17 September 1993.

Chelid fossil shell fragments are common in the Plio–Pleistocene deposits throughout Australia (e.g. in the Pliocene and Pleistocene deposits of the Darling Downs; Molnar 1982) but few are sufficiently complete to permit a detailed comparison with the shells of living species (Gaffney 1981).

In May, 1984 exploration of eroded fluviatile deposits exposed in the watershed of the Gregory River on Riversleigh Station, northwestern Queensland, revealed several sites that produced fossil vertebrates. One of these, now known as Terrace Site, produced abundant remains of chelid turtles as well as the Pleistocene marsupial *Diprotodon optatum*, unidentified macropodoids, murids, crocodilians, lacertilians, fish and invertebrates (bivalves and gastropods). Preliminary accounts of the discovery of Terrace Site have been given in Archer, Hand and Godthelp (1986).

From approximately 30cm above the base of the palaeochannel, in a layer with abundant bivalves and mammal bone fragments, a nearly complete although somewhat crushed chelid shell was recovered. It is sufficiently well preserved to enable comparison with a wide range of living chelids and is the basis for the species described herein.

Additional vertebrate remains from this deposit will be reported elsewhere (Godthelp, in preparation; Willis and Archer 1990; Willis, in preparation).

The anatomical terminology used in this paper follows that employed by (Gaffney 1977). That of modern chelid taxonomy follows Cogger (1993) and Obst (1986). Qualitative and quantitative methods of analysis follow Auffenberg (1976).

Methods

After being exposed in the deposit, the specimen was hardened with aquadhere, braced and secured in a plaster jacket. In the laboratory, various sections of the shell, defined by post-depositional crushing, were reconstructed using aquadhere. Measurements were made with dial calipers to the nearest millimetre.

Measurements and abbreviations used here are as follows:

Carapace

Anterior Carapace Width (ACW) = the anterior width of the carapace measured from the most anterior points of the $M_2 - M_3$ sutures.

Width of V_1 (V_1W) = the maximum width of the first vertebral scute.

Length of V_1 (V_1L) = the maximum length of the first vertebral scute.

Width and Length of Subsequent Scutes (Indicated by the appropriate subscript).

Length of C_1 (C_1L) = the maximum length of the first costal scute.

Plastron

Total Plastron Length (TPL) = measured in parallel to the midline from the most anterior to most posterior part of the plastron.

Anterior Plastron Length (APL) = measured in parallel to the midline from the most anterior portion of the plastron to the anterior margin of the bridge.

Bridge Width (BW) = the width of the bridge at the junction of the plastron.

Posterior Plastron Length (PPL) = measured in parallel to the midline from the most posterior portion of the plastron to the posterior margin of the bridge.

Intergular Width (IW) = the width of the intergular measured along the anterior margin of the plastron.

Intergular Length (IL) = the maximum length of the intergular scute.

Gular Width (GW) = the width of the gulars along the anterior margin of the plastron.

Gular Length (GL) = length of the gular-intergular suture.

Intergular Insertion (II) = the distance along the midline that the intergular scute penetrates between the humeral scutes i.e. measured from a line level with the posterior ends of the gulars to the posterior end of the intergular.

Humeral Length (HL) = the length of the humeral scutes along the midline.

Pectoral Length (PL) = the length of the pectoral scutes along the midline.

Abdominal Length (AL) = the length of the abdominal scutes along the midline.

Femoral Length (FL) = the length of the femoral scutes along the midline.

Anal Length (AnL) = the length of the anal scutes along the midline.

Anal Width (AW) = the distance between the most posterior parts of the opposing anal scutes.

Epiplastron Length (EpL) = the length of the epiplastron bones along the midline.

Entoplastron Length (EnL) = the maximum length of the entoplastron.

Entoplastron Width (EnW) = the maximum width of the entoplastron.

Hypoplastron Length (HyL) = the length of the hypoplastron bones along the midline.

Comparative Specimens Examined

Many of the comparative specimens of modern species examined during this study are lodged in the herpetological collections of the Australian Museum as follows:

Emydura australis: R20737, R72786, R72787.

Emydura krefftii: R14925.

Emydura macquarii: R1188, R6789, R81477, R85727, R104335, R123049

Emydura novaeguineae: R5042, R24460.

Emydura signata: R58588, R58589, R96716.

Elseya dentata: R3699, R3700, R31728, R36998, R40181,

Elseya latisternum: R20330–20345,R21224, R21485, R21570–21572, R37657–37665, R43530, R43542, R81958.

Rheodytes: R125481

Other specimens of these species were examined from the authors' collections. A specimen of *Pseudemydura umbrina* was examined from the Western Australian museum (WAM 13744). A specimen of the alpha taxon turtle was examined from John Cann's collection.

Systematics

Order: Testudines Linneus, 1758

Infraorder: Pleurodira (Cope, 1868)

Family: CHELIDAE Gray, 1825

Genus: ***Emydura* Bonaparte,** 1836

Emydura lavarackorum White & Archer n. sp. (Figs 1,2,3 and 4)

Holotype:

Queensland Museum Palaeontological Collections no. F 24121, an associated almost complete plastron, partial carapace and pelvic fragments collected 9th May, 1986, by J. and S. Lavarack.

Type locality and age:

Terrace Site, an excavation in fluviatile sediments exposed on the south bank of the Gregory River, Riversleigh Station, northwestern Queensland, approximately 200km northwest of Mount Isa. More precise locality data are recorded and may be available on application to the Queensland Museum or the University of New South Wales. The presence in the sediments of material referable to *Diprotodon optatum* and no other index fossil indicative of any other period of time is the basis for interpreting the deposit to be Pleistocene in age. No more precise age determination is available at this time although samples suitable for radiocarbon dating have been collected.

Diagnosis:

This species differs from all others in the following combination of features. The first

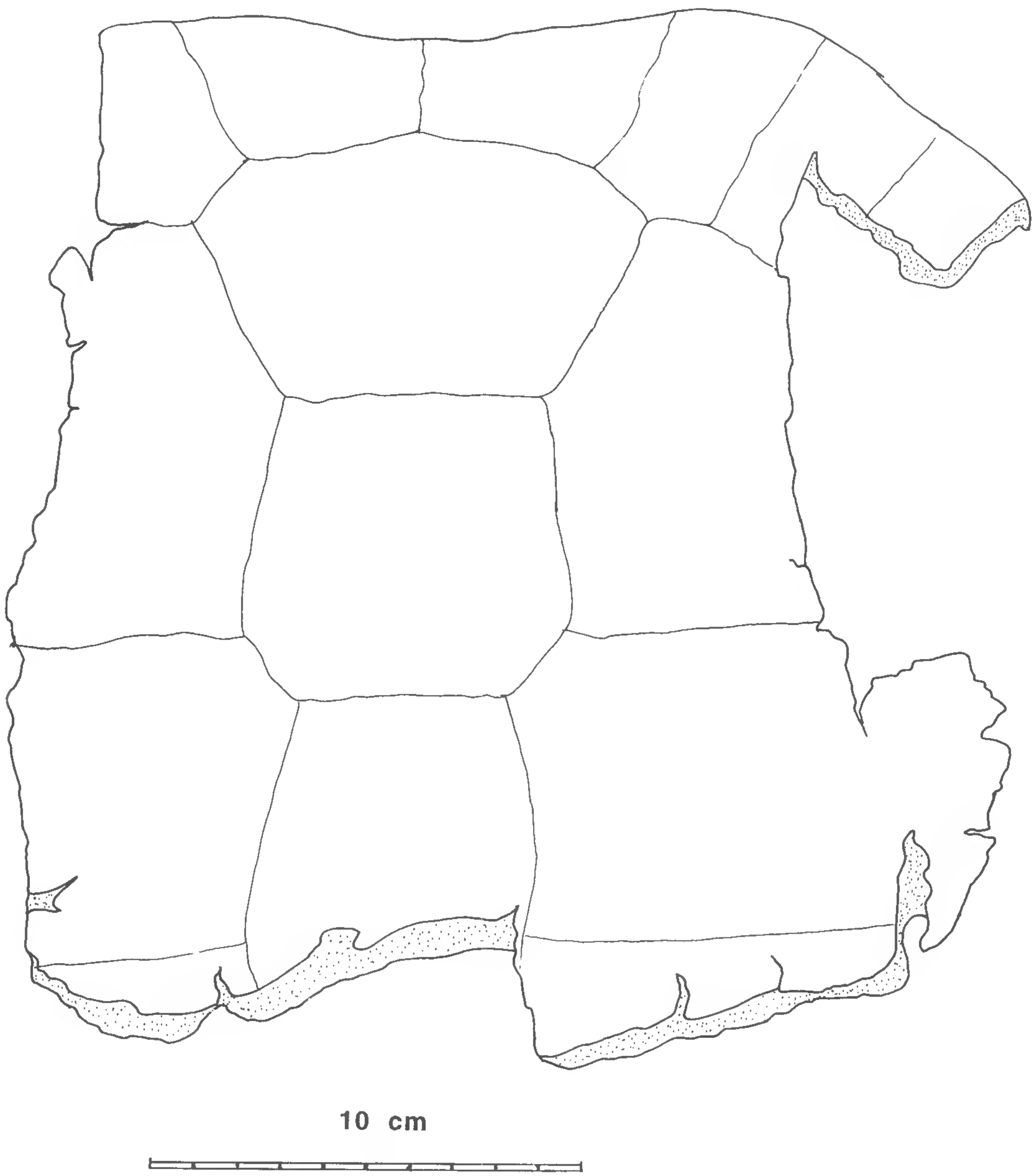

FIGURE 1. Dorsal view of anterior carapace of *Emydura lavarackorum*.

vertebral scute (V_1) is much wider than V_2. Vertebral scutes V_2 and V_3 are rectangular, being longer than they are broad, with very small projections into the costal junctions (Fig.1). The humeral–pectoral seam is sigmoidal rather than straight. The anterior straight edge of the carapace is wide and incorporates the two left and right marginal scutes (before the carapace curves posteriorly). The anterior bridge struts are unusually thick. The anterior edge of the gular is as wide as the anterior edge of the intergular. The intergular is long and deeply divides the humeral scutes. The intergular intrusion between the humerals is greater than the gular length. The intergular scutes narrow at the anterior edge of the carapace. The bridge is broad (BL:TPL = 0.29). The acetabulum is circular and is contributed to equally by all three pelvic bones. The acetabulum has a diameter of 25 mm. The upper (ilial) lip of the acetabulum is raised and overhanging whereas the lower lip (ischium and pubis) is less pronounced.

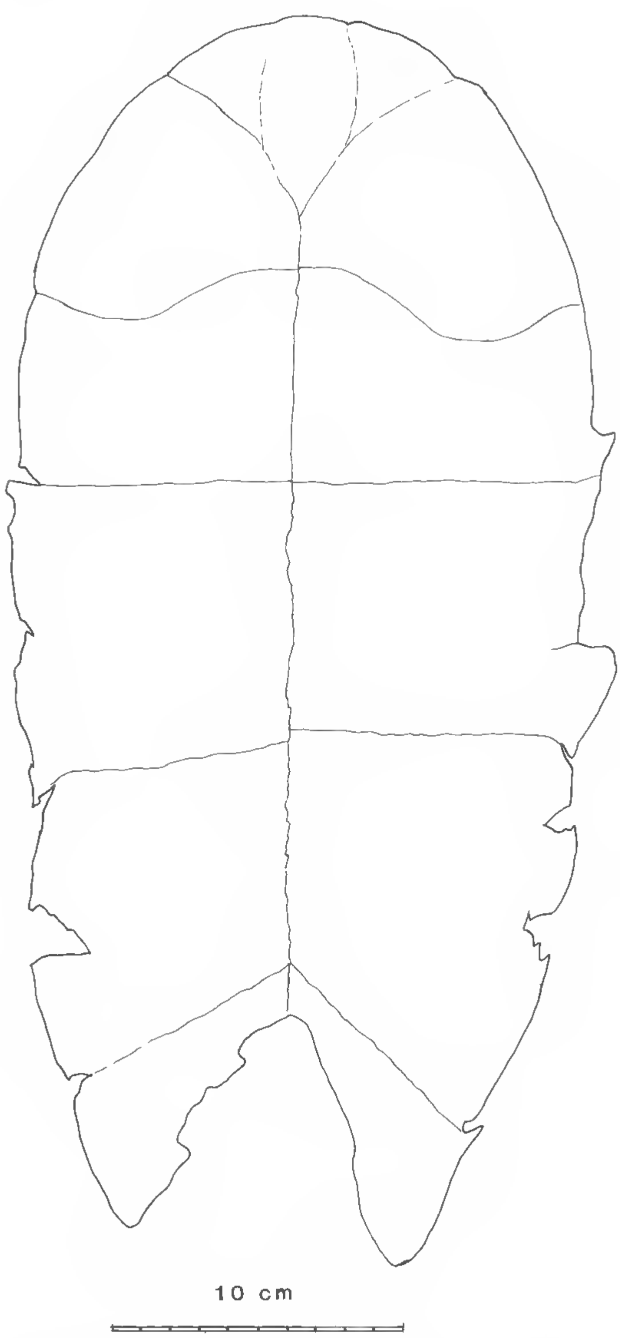

FIGURE 2. External view of plastron of *Emydura lavarackorum*

Etymology:

The species name is in honour of Sue and Jim Lavarack, hard-working volunteers who, besides having collected the holotype (Archer 1988) and supervised excavations at Terrace Site for five years, have maintained a continuous supportive role in the work done at Riversleigh and on Riversleigh materials which they have helped to prepare in Sydney.

Description:

The plastron is long (390 mm) and almost complete except for some medial gaps in the anal region (Fig. 2). The plastron is evenly rounded at its anterior end. The posterior end of the plastron terminates with two pointed anal projections. The anterior lobe of the plastron is broader (maximum width 165 mm) than the posterior lobe (maximum width 154 mm).

The endoplastron is wider (EnW = 58 mm) than it is long (EnL = 45 mm) (Fig. 3). The epiplastral–hypoplastral suture is sigmoidal. The hypoplastra are the longest bony elements in the plastron (HyL = 105 mm). Of the epidermal scutes, the intergular is the most distinctive. It completely separates the gulars and penetrates deeply between the humerals. The humeral–humeral seam is only 15 mm long whereas the humerals have a maximum height of 87 mm. The longest scutes are the abdominal (A_1 = 105 mm), followed by the femoral scutes (F_1 = 95 mm), pectoral scutes (PL = 67 mm), anal scutes (AnL = 66 mm), intergular (IL = 62mm) and finally the humerals (HL = 15 mm).

The humeral–pectoral seam is sigmoidal, the most anterior sections being at the midline and at the extreme margins. The intergular has a maximum width of 26 mm but is only 19 mm wide along the anterior edge of the plastron. The gulars are small being only a little wider (GL = 28 mm) than the intergular. The intergular extends most of the way between the humerals. The intergular intrusion is longer than the gular length.

The carapace is large and flat along the ventral surface. The leading edge of the carapace is almost

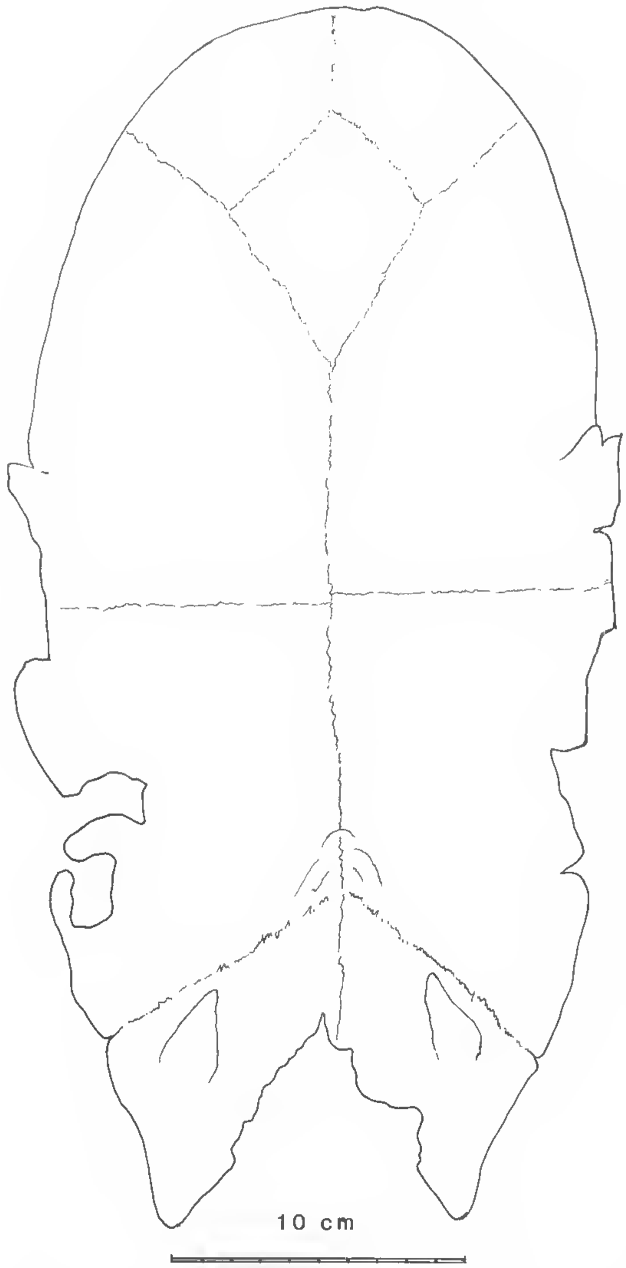

FIGURE 3. Internal view of plastron of *Emydura lavarackorum*.

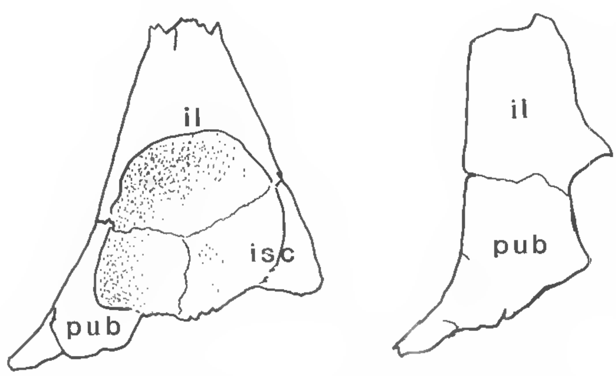

FIGURE 4. Acetabular view and lateral view of the left hip of *Emydura lavarackorum*.

straight and does not curve posteriorly until the suture line between the second and third marginal scutes. A precentral (nuchal) scute is absent. The broad anterior edge of the carapace is reflected by an expansion of the V_1 scute (maximum width 103 mm). This scute is almost twice as wide as the second vertebral scute (width 56 mm). V_1 (height 70 mm) is not as high as V_2 (height 87 mm). The third vertebral scute is incomplete but appears to be of similar proportions to the V_2 scute. The projections of the vertebral scutes between the costals is minimal. The first costal scute (C_1) is higher (95 mm) than C_2 (83 mm in height). It was not possible to measure the width of the costals.

The recess for the insertion of the anterior bridge strut on the undersurface of the carapace is steeply angled across the first pleural bone and is not in line with the raised process that forms the mid-pleural wall. The recess abuts the second peripheral bone and forms most of the base of the third peripheral (Fig 5). The dorsal fork of the transverse process on the first thoracic vertebra sweeps backwards to form the top of the mid-pleural wall.

A major section of the left pelvis comprising of the ischium, ilium and pubis was measured. The piece was 55 mm long and 20 mm wide at the ilial fracture. It was 35 mm wide at a position level with the acetabulum (which had a diameter of 25 mm).

The acetabulum is quite deep and is overhung by a pronounced upper ridge formed by the extension of the ilial ridge (Fig 4). The lower lip of the acetabulum has a much weaker rim formed a joining ridge continuous between the pubis and ischium.

Measurements (mm) of the holotype:

ACW = 210; V_1W =105; V_1H = 72; V_2W = 65; V_2H = 87; C_1H = 95; C_2H = 83; TPL = 390; APL = 110; BW = 115; PPL = 165; IW = 20; IH = 62; GW = 30; GL = 30; II = 36; HL = 15; PL = 67; AL = 105; FL = 95; AnL = 66; AW = 93; EpL = 30; EnH = 45; EnW = 58; HyL = 105.

Comparisons and discussion

The Riversleigh fossil turtle is placed in the Chelidae because of the evidence of pelvic fusion to the shell and the absence of mesoplastra and neural bones (Gaffney 1977).

Within the Chelidae, the Riversleigh turtle is placed in the genus *Emydura* on the basis of a recently identified synapomorphy. This feature relates to the insertion of the anterior bridge into

TABLE I. Shell characteristics of Australian short-necked chelids.

Feature	*Rheodytes*	Alpha	*Elseya dentata*	*Elseya latisternum*	*Emydura kreffti*	*Emydura macquarii*	*Pseudemydura*
Relative Length of Anterior Plastron	60–70% of the length of the posterior plastron	66% of the length of the posterior plastron	80–90% of the length of the posterior plastron	82–95% of the length of the posterios plastron	75–88% of the length of the posterior plastron	75–85% of the length of the posterior plastron	45–65% of the length of the posterior plastron
Relative Width of Anterior Plastron	Narrower than the posterior plastron	Wider than posterior plastron	Narrower than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron	Wider than the posterior plastron
Bridge Width	Narrow: shorter than the length of ant. plastron	Narrow: shorter than the length of ant. plastron	Broad: longer than the anterior plastron	Narrow: shorter than length of ant. plastron	Broad: longer than the anterior plastron	Broad: longer than length of ant. plastron	Broad: longer than length of ant. plastron
Bridge Buttresses	Pronounced inguinal and axillary buttressing	Pronounced inguinal and axillary buttressing	No raised buttressing	No raised buttressing	No raised buttressing	No raised buttressing	No raised buttressing
Shape of Recess for Anterior Bridge Struts	Recess in line with mid pleural wall	Recess in line with mid pleural wall	Recess in line with mid pleural wall	Recess in line with mid pleural wall	Recess angled above mid pleural wall	Recess angled above mid pleural wall	Recess in line with mid pleural wall
Relative Width of Intergular	Narrower than the gulars	Narrower than the gulars	Narrower than the gulars	Wider than the the gulars	Narrower than the gulars	Narrower than the gulars	Wider than the gulars
Extent of Gular Penetration	Intergular penetrates 1/3 between humerals	Intergular penetrates half way between gulars	Intergular penetrates half way between humerals	Intergular penetrates half way between humerals	Virtually no separation of humerals by intergular	Intergular penetrates half way between the humerals	Intergular complete

the ventral surface of the carapace. The recess for the anterior bridge is angled steeply backwards to reach the raised process that forms a transverse wall across the floor of the first pleural bone. In the other chelid genera, the recess is itself transverse and so forms a near continuous line with the mid-pleural wall (Fig. 5). The Riversleigh *Emydura* has this derived characteristic.

Osteological comparisons (e.g. Gaffney 1977) of the shells and skulls of *Emydura* and *Elseya* have highlighted the great degree of similarity between these two genera. Current taxonomy (Obst 1986, Cogger 1993) recognises two species of *Elseya* and 6 species of *Emydura*. The diagnostic features that are used to identify the genera and species are features that include soft anatomy, skull ridges and plastral scute patterns. Legler (1985) and Georges and Adams (1993) have cast doubts about the validity of current concepts of these genera, especially *Elseya* which appears to be paraphyletic. On the basis of the carapacial synapomorphy identified in this paper *Emydura*, however, appears to be monophyletic.

The Riversleigh *Emydura* is a large turtle compared to other Australian chelids. It has a plastral length of 39 cm and hence would most likely have had a carapace length of approximately 41 cm. In comparison, the largest measured extant chelid is *Elseya dentata*. Cann (1986) has reported adults of this species with carapace lengths of up to 36.5 cm. The largest *Emydura* species is *E. macquarii* which may reach shell lengths of up to 40 cm (Cogger 1993).

In the extant Australian chelid species, the bridge typically occupies between 20 and 30% of the plastron length (Table 1). *Emydura macquarii* and *E. signata* have the narrowest bridge (20–23% of the plastron length) of all *Emydura* species. In contrast the bridge of *E. kreffti* is particularly broad and varies between 28 and 33% of the plastron length In the Riversleigh turtle, the bridge is wide (30% of the plastron length).

The bridge struts of the Riversleigh turtle are unusually thick. The anterior bridge struts are 2.15 cm wide at the base and almost 1cm wide in the middle. The largest comparative chelid specimen that was available for measurement was a deep-shelled snapper (*E. dentata* carapace length 28.5 cm, R40181). The anterior bridge strut of this animal was only half as massive.

Carapace shape varies in *Emydura*. Species such as *E. macquarii* and *E. signata* have broad, low domed carapaces that are expanded at the rear. In the range of shell shapes *E. kreffti* represents the other extreme and has a high domed carapace that is not expanded at the rear (Goode 1966). *E. lavarackorum* is intermediate in shell shape and has a carapace that is not evenly rounded.

In all species of *Emydura* the gular scutes of the plastron are completely divided by the intergular (Table 1). *Emydura* turtles also show partial separation of the humerals by the intergular, with the degree of separation being less than half of the mid-humeral length. Of the other Australian chelid genera, only in *Pseudemydura* does the intergular also completely divide the humerals. The intergular of *Elseya latisternum* produces the weakest separation of the humerals and barely intrudes between the humerals. *Emydura lavaracki* is most distinctive in this regard as the intergular deeply divides the humerals without completely separating them.

In the extant Australian *Emydura*, the arrangement of the pelvic bones around the acetabulum is similar. Here the ilium, ischium and

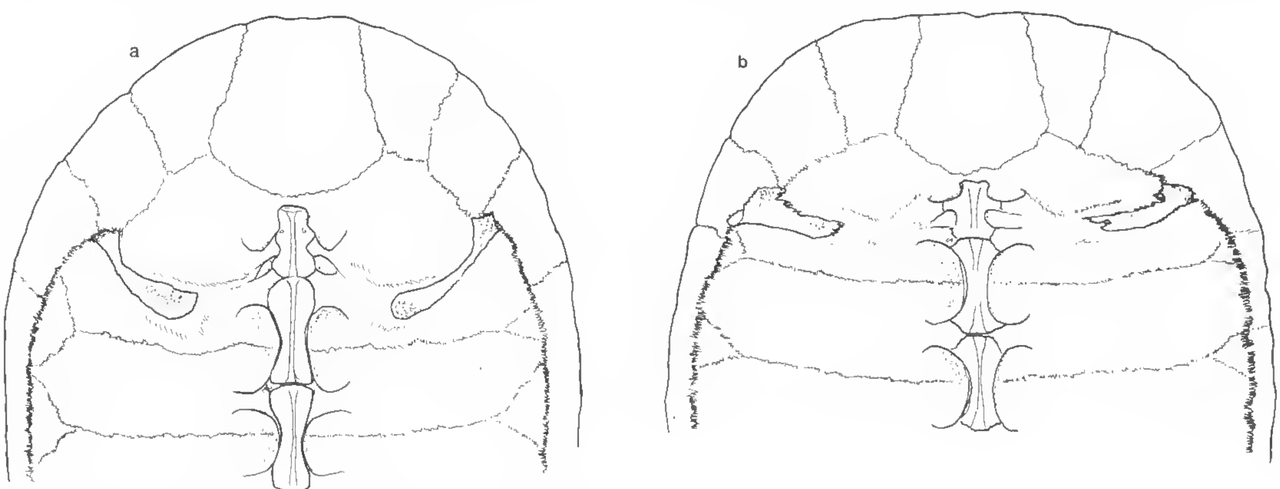

FIGURE 5. View of the undersurface of the anterior carapaces of *Emydura kreffti* (a) and *Elseya latisternum* (b).

pubis contribute almost equally to the composition of the acetabulum. This arrangement is also present in *Emydura lavarackorum*. In the extant species of *Emydura* the upper and lower rim of the acetabulum are equally protuberant. *E. lavaracki* is different in this regard as the upper lip of the acetabulum is more substantial than the lower lip. This means that the acetabulum is relatively deeper in this species.

The conventional guide for determining species within the genus *Emydura* is based on features of soft anatomy, shell shape and distribution (Cogger 1993). Other shell features have been used such as the relative length of the plastron compared to the carapace, the relative length of the anterior plastron compared to the posterior plastron and the relative width of the bridge (Goode 1966). *E. macquarii* has a plastron that is noticeably shorter than the carapace (80–85% of the carapace length). By way of contrast, *E. kreffti* has a longer plastron that ranges from 85–95% of the carapace length. Based on the shell reconstruction of *E. lavarackorum* the plastron appears to be about 95% of the length of the carapace. In some species of *Emydura*, such as *E. macquarii*, the anterior plastron is conspicuously shorter than the posterior plastron. In comparison, *E. kreffti* has anterior and posterior plastron segments that are almost equal in length. *E. lavarackorum* the anterior plastron is much shorter (67%) than the posterior plastron.

In view of the many evidently significant differences between the Riversleigh fossil species and any others referred to this genus, we have no hesitation in describing the fossil form as the new species *Emydura lavarackorum*.

Although we have placed this species in the genus *Emydura* on the basis of shell morphology it is apparent that it is not particularly closely related to any of the other species in this genus. In two respects, this Pleistocene chelid is unlike all Australian short-necked turtles: the massive expansion of the V_1 scute and the deep extension of the intergular between the humerals. In these features, the Riversleigh form more closely resembles the long-necked chelids. Further clarification of the intrafamilial affinities of the Riversleigh form may have to await discovery of cranial material.

Acknowledgments

We wish to acknowledge the vital financial support the Riversleigh Project has had from: the Australian Research Grant Scheme (Grant PG A3 851506P); the National Estates Scheme (Queensland); the Department of Environment and Arts; Wang Australia Pty Ltd; ICI Australia Pty Ltd; the Queensland Museum; the Australian Geographic Society; Mount Isa Mines Pty Ltd; and Surrey Beatty & Sons Pty Limited. Critical logistical support in the field and laboratory has been received from the Riversleigh Society, the Friends of Riversleigh, the Royal Australian Air Force, the Australian Defence Force, the Queensland National Parks and Wildlife Service, the Riversleigh Consortium (Riversleigh being a privately owned station), the Mount Isa Shire, the Burke Shire, the Northwest Queensland Tourism and Development Board, the Gulf Local Development Association, PROBE and many volunteer workers and colleagues including Dr Suzanne Hand and Henk Godthelp who helped to recover the holotype. Alan Rackham Snr and Alan Rackham Jnr discovered the Terrace Site in the first place. Among the volunteers who helped at the 1984 Riversleigh Expedition, special thanks are extended to Bruce Armitage, John Courtenay, Martin Dickson, Joy Dohle, Archie Daniels, Bernie Jennings, Leslie Hobbs, Bill Lockwood, Audrie and Harry Macintosh, Reg Markham, Melody Nixon, Ron Norman, Jim and Sue Lavarack, Brian, Bronwen and Dan O'Dwyer, Lazar Radanovich, Jim Ross, Mary Sandilands, Donald and Sue Scott-Orr, Jack Struber, Dr Steven Waite and Shirley Webster.

References

AUFFENBERG, W. 1976. The genus *Gopherus* (Testudinidae) Part 1. Osteology and relationships of extant species. *Bulletin of the Florida State Museum of Biological Sciences* **20**: 47–110

ARCHER, M., HAND, S. H. & GODTHELP, H. 1986. 'Uncovering Australia's Dreamtime'. Surrey Beatty & Sons Pty Ltd: Sydney.

ARCHER, M. 1988. Riversleigh: window into our ancient past. *Australian Geographic* **9**: 40–57 [illustration of the holotype of *Emydura lavarackorum* being collected at Terrace Site by J. Lavarack, p. 53].

CANN, J. 1978. 'Tortoises of Australia'. Angus & Robertson, Sydney.

COGGER, H. G. 1993. 'Reptiles and Amphibians of Australia'. 5th ed. Reed, Sydney.

COGGER, H. G., CAMERON, E. E. & COGGER, H. M. 1983. Amphibia and Reptilia. *In* 'Zoological Catalogue of Australia'. Vol. 1. Ed. D. W. Walton. Bureau of Flora and Fauna: Canberra.

GAFFNEY, E. S. 1977. The short-necked family Chelidae: a theory of relationships using shared derived characters. *American Museum Novitates* **2620**: 1–28.

GAFFNEY, E. S. 1981. A review of the fossil turtles of Australia. *American Museum Novitates* **2720**: 1–38.

GEORGES, A. & ADAMS, M. 1993. A phylogeny for Australian chelid turtles based on allozyme electrophoresis. *Australian Journal of Zoology* **40**: 453–476.

GOODE, J. 1966. 'Freshwater Tortoises of Australia and New Guinea'. Longman Press.

LEGLER, J. M. 1985. Australian chelid turtles: Reproductive patterns in wide ranging taxa. Pp. 117–123 *in* 'Biology of Australian Frogs and Reptiles'. Eds G. C. Grigg, R. Shine and H. Ehmann. Royal Zoological Society of N.S.W. Surrey Beatty & Sons.

LEGLER, J. M. & CANN, J. 1980. A new genus and species of Chelid turtle from Queensland, Australia. *Contributions of the Science and Natural History Museum of Los Angeles County* **324**: 1–18.

MOLNAR, R. 1982. Cenozoic Fossil Reptiles in Australia. Pp. 228–233 *in* 'The Fossil Vertebrate Record of Australasia'. Eds P. V. Rich and E. M. Thompson, Monash University Press, Victoria.

OBST, F. J. 1986. 'Turtles, Tortoises and Terrapins'. Druckerei Fortschritt Erfut, Leipzig, G.D.R.

WILLIS, P. & ARCHER, M. 1990. A Pleistocene longirostrine crocodile from Riversleigh; first occurrence of *Crocodilus johnstoni* Krefft. *Memoirs of the Queensland Museum* **28**: 159–164.